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EDWIN DUNKIN, F.R.S., President, in the Chair.

Rev. Thomas Perkins, M.A., The School, Shaftesbury, Dorset,
was balloted for and duly elected a Fellow of the Society.

On some Points of Difference between the Harvard and Oxford Stellar Photometry. No. 1. By Prof. C. Pritchard., D.D., F.R.S.

The second part of the *Harvard Photometry* recently published contains, among many other subjects of interest, a very elaborate series of comparisons of the magnitudes of stars as estimated or measured by a great variety of astronomers. Among these is a comparison between the photometric measures made at Harvard with the Meridian Photometer and those made with the Wedge Photometer at Oxford. Such comparisons of catalogues may possess a very great scientific value.

In the course of the above inquiry, and as one result of the comparison referred to, the following passage occurs: * “The results derived from the Wedge Photometer should theoretically be affected by the brightness of the background, and this effect appears actually to occur in the present instance,” i.e. in the catalogue of photometric magnitudes published in vol. xlvii. of the *Memoirs* of the R.A.S., but which, it is important to observe, forms but a small part of the completed work.

I confess that these statements greatly surprised me, because from the very first application of the method to its final completion I had watched the progress of the work with a scrupulous and jealous care, lest some systematic error might after all lurk either in the principles of the instrument or in the mode of its use. In particular I had considered any possible effects arising

* *Harvard Photometry* (“Annals of Harvard College Observatory,” vol. xiv.), p. 493.

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from the varying brightness of the background against which the stars were apparently projected, and specially I felt it necessary to be *practically* assured (irrespective of any theory) that even bright Moon light, or the total absence of the Moon from the sky, produced no sensible effects on the determination of relative magnitude. If such be the case (as it in reality is) with bright Moon light, then the slighter variations of the background arising from variations in stellar density (the form in which the objection is made) might reasonably be expected, *a fortiori*, to be harmless. Nevertheless, I have also *practically* assured myself that such is the case as to the observations themselves.

First, with regard to the effects of Moon light on the point of extinction of any particular star. During the three years through which the observations extend, *Polaris* has been extinguished many thousand times. Accordingly I have divided these extinctions into four periods, corresponding to the four phases of the Moon, and, as a result, I find that whatever may have been the phase, the mean point of wedge-extinction of *Polaris* remains sensibly the same. This will be rendered evident by an inspection of the following table.

Point of Wedge-Extinction of Polaris in reference to the Moon's age.

Moon's Age.	Mean Wedge reading for Extinction.	No. of Ex-tinctions.
d d	inches	
0-7	4.77	1050
7-14	4.76	1125
14-21	4.74	1675
21-28	4.75	1275

In the foregoing table, column one gives the Moon's quarterly phase, during which the extinctions were made. The second column gives the mean reading in inches, measured from the extremity of the wedge, of the point of extinction. The last column gives the number of extinctions employed in obtaining the mean. The observations in question were made with one wedge applied to a telescope of 4 inches aperture. Similar observations in number and principle were also made with an aperture of 2 inches; and again, with another wedge and another telescope of 3 inches and $1\frac{1}{2}$ inch aperture. It is only necessary to add that a variation of one-hundredth of an inch in the wedge reading, implies a variation of one-fiftieth of a magnitude.

I come next to the less salient case of a varying brightness of the field, arising from varying stellar density in different portions of the sky, and the question here arises, "Is it a fact that the Oxford results depend, to any extent, on the brightness of the field" * as arising from this cause? The implication here made is, after all, indefinite in amount, and possibly necessarily

* *Harvard Photometry*, p. 502.

so, owing to the extremely small number of measures then published in some of the groups. Be this as it may, in the *Harvard Photometry* the heavens are divided into thirty-six portions of approximately equal area, and the corresponding stellar densities in each of these are tabulated as obtainable both from the *Harvard Photometry* and the more extended tables of the *Durchmusterung*. The results of the *Harvard Photometry* are then practically assumed as a Standard, and the mean deviations of the Oxford results from the Harvard results in each of the thirty-six divisions are tabulated,* and then, as a final result, the conclusion given above is drawn.

The three densest portions of the sky are designated as B_8 , C_3 , C_{10} ; that is approximately the regions of *Cygnus*, *Taurus* and *Orion*, and *Aquila* respectively. If, then, the systematic error attributed exists, we should expect to find it most pronounced by deviation from the Standard in these regions; but in point of fact the deviations from the Standard in the region B_8 stand, not first, but fourth, in numerical order; and in the other two, C_3 and C_{10} , the deviations from the assumed Standard are inconspicuous and singularly small. On the other hand, where the deviations from the Harvard Standard are most pronounced, viz. in D_5 , D_3 , C_4 (viz. in *Hydra*, *Monoceros*, and *Canis Minor*), the sky is in D_5 and C_4 below the average of brightness; the region D_3 is slightly above the average stellar density. From this investigation I cannot avoid the conclusion that there is no sufficient ground (from the data published) for suggesting the existence of a systematic error in the *Oxford Photometry* from the cause referred to. On an examination of the *whole* Oxford Catalogue, now on the eve of publication, and containing a large number of the fainter stars, where the effect would be greatest (if any), I find still stronger grounds for denying the existence of any such small systematic error as the one referred to.

Lastly, in the *Harvard Photometry* a systematic error is suggested as existing *generally* in catalogues of magnitude, depending upon the magnitude of the stars. I cannot say whether the Oxford measures are included in this suggestion or not. That it does exist in estimations made by the unaided eye is, I think, very probable; and, in fact, it was long ago suggested as natural and even proper by Sir John Herschel, but upon a very elaborate examination of the 3,000 stars contained in my completed catalogue, I have found not the slightest trace of any systematic deviation of measure, when compared with the Harvard Catalogue, due to the brightness of the objects measured.

As a final result of these investigations I claim on behalf of the wedge photometer that no systematic error exists, either in relation to the varying brightness of the field of view or to the brightness of the stars themselves.

It will be remarked that the inquiry as to the influence of

* *Harvard Photometry*, p. 490.

variable stellar density on the Oxford Photometry, depends solely on a comparison of the Oxford work with the Harvard Catalogue, taken as the Standard of reference. It appears, therefore, to me to be a matter of scientific importance herein, to institute some investigation regarding the amount of reliance which is to be placed on the accuracy of the magnitudes assigned to single stars in the Standard itself; and this investigation can be made alone by means supplied in the published volume. Now, by far the greater number of the Harvard adopted magnitudes is derived from the mean of separate determinations made on *three* different nights. The residuals of these three determinations from the adopted mean magnitude are given in the General Catalogue, Table xxvii. That these three residuals inadequately express the amount of exactness of the adopted mean magnitude, appears from the following considerations. In many instances a much greater number of measures of magnitude is given, obtained on many different nights, sometimes extending to as many as fifteen or twenty. *Sirius*, *Arcturus*, &c., are instances of this. It is from these numerous measures that we can obtain some indication of the reliance which is to be placed on a determination derived from three only. By way of illustration, a fair criterion of the value of transit observations (simply considered as transits) may be derived by comparing the adopted mean obtained from observations over nine wires, with the results obtainable from those over any three of the wires.

If this sort of test be applied to the *Harvard Photometry*, notable differences in the magnitude of the same star will be found to occur with frequency. The measures derived from *three* successive nights are taken, because it is from the measures of three successive nights alone, that the vast bulk of the magnitudes in the Catalogue is derived, provided only no suspicious circumstances have occurred during the three said successive nights. As an example, and for the sake of clearness, take the observations of *Sirius*, No. 1275, Table xxvii. They are sixteen in number. The adopted magnitude is -1.43 . Now, if the magnitude of *Sirius* had been derived from the third, fourth, and fifth nights of observation alone, it would differ from the finally adopted magnitude by $.33$ mag.; and if the measures on the sixth, seventh, and eighth nights only be taken, the magnitude would differ by $.30$ in the other direction, i.e. there would be a difference of six-tenths of a magnitude between the two results, and no suspicious circumstance is recorded as having attracted the attention of the observer, except, perhaps, in the third series. This seems to indicate that great exactness cannot be necessarily conceded to the Meridian Photometer, when observations are limited to three nights only. Further still, there are instances in which a magnitude derivable from even as many as seven successive nights, sensibly differs from the finally adopted magnitude. The measures of ϵ *Orionis*, *Pollux*, &c., will be found

to support this statement, even among the few stars comprised in the subjoined table.

The following table has been constructed on the principles indicated above, and it applies to all the brighter stars visible in the northern heavens, from *Sirius* down to stars comparable in lustre with *Polaris*.

Variations in the magnitude of the bright stars, from Sirius to Polaris, as derivable from any three successive concluded measures of magnitude in the Harvard Photometry, "H. P."

Star's Name.	Least Mag. of Star in H.P.	Greatest Mag. of Star in H.P.	Diff. of Mag.	Adopted Mean Mag.	No. of Night.
Sirius ...	—1·76	—1·13	0·63	—1·43	16
Arcturus ...	—0·20	0·36	0·56	0·03	13
Capella ...	0·08	0·31	0·23	0·18	16
Rigel ...	0·15	0·42	0·27	0·32	15
α Lyrae ...	0·09	0·36	0·27	0·19	15
Procyon ...	0·36	0·76	0·40	0·46	15
α Orionis ...	0·81	1·08	0·27	0·91	10
Aldebaran ...	0·80	1·17	0·37	1·00	16
α Aquilæ ...	0·64	1·14	0·50	0·97	15
Antares ...	0·89	1·23	0·34	1·06	13
Spica ...	1·06	1·63	0·57	1·23	13
Pollux ...	0·75	1·39	0·64	1·12	15
Fomalhaut ...	1·09	1·46	0·37	1·26	16
Regulus ...	1·29	1·52	0·23	1·42	15
α Cygni ...	1·20	1·77	0·57	1·47	13
ϵ Canis Maj. ...	1·22	1·72	0·50	1·49	17
Castor ...	1·26	1·69	0·43	1·56	15
γ Orionis ...	1·73	2·13	0·40	1·86	16
ϵ Orionis ...	1·56	1·89	0·33	1·76	16
ζ Orionis ...	1·62	2·12	0·50	1·89	15
β Tauri ...	1·80	2·13	0·33	1·90	15
η Ursæ Maj. ...	1·75	2·12	0·37	2·02	13
λ Scorpii ...	1·48	1·91	0·43	1·68	6
ϵ Ursæ Maj. ...	1·52	2·02	0·50	1·85	13
α Ursæ Maj. ...	1·86	2·06	0·20	1·96	15

Star's Name.	Least Mag. of Star in H.P.	Greatest Mag. of Star in H.P.	Diff. of Mag.	Adopted Mean Mag.	No. of Nights.
α Persei ...	1.77	2.04	0.27	1.94	19
β Aurigæ ...	1.90	2.37	0.47	2.07	14
δ Canis Maj. ...	1.65	1.98	0.33	1.85	15
θ Centauri ...	1.70	1.86	0.16	1.73	6
α Androm. ...	1.85	2.31	0.46	2.08	16
Polaris ...				2.15	
γ Geminor. ...	1.83	2.10	0.27	2.00	17
β Canis Maj. ...	1.84	2.18	0.34	2.01	15
α Hydræ ...	1.85	2.22	0.37	2.02	15
α Arietis ...	1.91	2.21	0.30	2.04	19
ζ Ursæ Maj. ...	2.18	2.51	0.33	2.38	13

In the above table the second column contains the least magnitude of the particular star, as derived from any three consecutive residuals and the finally adopted magnitude given in the general catalogue of the *Harvard Photometry*. The third column is the greatest magnitude derived in a similar manner. The fourth column contains the range of magnitude deduced from the foregoing consecutive combinations. The fifth column contains the magnitude ultimately adopted, and the sixth the number of nights on which the successive measures were made.

Some explanation of the serious discrepancies thus disclosed by the preceding table, and beyond my own power now to give, seems very desirable.

In a short time from the present date the whole of the Oxford work will be published by the University, under the title of *Uranometria Nova Oxoniensis*; and it will then be my duty to compare its results with any other catalogues of a similar nature. At present, one further remark alone remains to be made. Whatever may be the criticisms to which the particular works completed at Harvard College and at Oxford may be fairly open, one thing appears to be certain—namely, that the application of Photometry to the determination of stellar lustre has made an enormous advance over the ancient methods of estimates by the unaided eye. Guided by the experience of some seventy thousand extinctions of stars made with the Wedge Photometer, I feel certain that on any single fair night, the apparent difference of the magnitudes of any two stars may be ascertained within the limits of an error not exceeding the tenth of a magnitude. I conclude with the expression of the hope that no remark made in the course of the present inquiry will be deemed as inconsistent with unfeigned respect for the remarkable ingenuity and unremitting labour which characterise every page of the *Harvard Photometry*.